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STUDIES IN
DIGITAL AUTOMATA
BY THE
COLLEGE OF ENGINEERING
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA 70303

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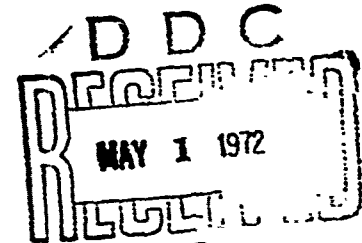
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Abstract

The period December I, 1971 through February 29, 1972 is covered in this progress report. The first four sections comprise an up-to-date list of publications, presentations, and reports. The final section presents summaries of the progress on the various research topics currently being pursued.

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The following is an up-to-date list of presentations,
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JOURNAL PUBLICATIONS

LSU-T-P1 "Optimum Tuning of Proportional Digital Control Systems," by A. M. Lopez, P. W. Murrill, and C. L. Smith, <u>Instruments and Control Systems</u>, <u>41</u>, No. 10 (October 1968), pp. 97-102, AD 678278, AFOSR 68-2441.

LSU-T-P2 "Gauging Performance Costs of Control Loop Hardware," by C. F. Moore, P. W. Murrill, and C. L. Smith, <u>Instrumentation Technology</u>, <u>15</u>, No. 11 (November 1968), pp. 69-72, AD 679838, AFOSR 68-2784.

LSU-T-P3 "Development of Dynamic Mathematical Models," by P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, September 9, 1968, pp. 117-120, AD 696712, AFOSR 69-2737TR.*

LSU-T-P4 "The Basis for Bode Plots," by P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, October 7, 1968, pp. 177-182.*

LSU-T-P5 "Frequency Response Data Yield Analytic Equations," by. P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, November 18, 1968, 165-169.*

LSU-T-P6 "Transient Response in Dynamic-Systems Analysis," by P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, December 16, 1968, pp. 103-106.*

LSU-T-P7 "Region of Acceptable Motion," By P. M. Julich, <u>IEEE Transactions on Automatic Control</u>, December 1968.

LSU-T-P8 "Simplifying Digital Control Dynamics for Controller Tuning and Hardware Lag Effects," By C. F. Moore, C. L. Smith, and P. W. Murrill, <u>Instrument Practice</u>, January 1969, pp. 45-49, AD 685989, AFOSR 69-0883TR.

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LSU-T-P11 "Pulse Testing Methods," by P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, February 24, 1969, pp. 105-108.*

LSU-T-P12 "Nonperiodic Inputs Provide Data for Frequency Response Models", by P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, March 10, 1969, pp. 111-116.*

LSU-T-P13 "Random Inputs Yield System Transfer Functions," by P. W. Murrill, R. W. Pike, and C. L. Smith, <u>Chemical Engineering</u>, April 7, 1969, 151-154. *

* These reports are contained in AD 696712, AFOSR 69-2737TR.

JOURNAL PUBLICATIONS (Continued)

LSU-T-P14 "Time Domain Specifications of Digital Controllers", by L. P. Neumann, C. L. Smith, and P. W. Murrill, Instruments and Control Systems, Vol. 42, No. 11 (May 1969), pp. 97-100, AD 689077, AFOSR 69-1409TR.

LSU-T-P15 "Frequency Response Data from Statistical Correlations", by P. W. Murrill, R. W. Pike, and C. L. Smith, Chemical Fngineering, May 19, 1969, pp. 195-200.*

LSU-T-P16 "Models for a Process Plant", by P. W. Murrill, R. W. Pike, and C. L. Smith, Chemical Engineering, June 16, 1969, pp. 97-100.*

LSU-T-P17 "Models for Process Equipment", ' '. W. Murrill, R. W. Pike, and C. L. Smith, Chemical Engineering, July 28, 1969, pp. 139-142.*

LSU-T-P18 "How to Apply Feedforward Control", by J. A. Miller, P. W. Murrill, and C. L. Smith, Hydrocarbon Processing, Vol. 49, No. 7, (July 1969), pp. 165-172, AD 696711, AFOSR 69-2371TR.

LSU-T-P19 "Algorithm for Computing Fourier Integrals Rapidly", by P. W. Murrill, R. W. Pike, and C. L. Smith, Chemical Engineering, August 25, 1969, pp. 125-128.×

LSU-T-P20 "Circular Arrays of Radial and Tangential Dipoles for Turnstile Antennas" by J. L. Hilburn, IEEE Transactions on Antennas and Propagation, Vol. AP-17, No. 5, Sept. 1969, AD 688081, AFOSR 69-1420TR, (same as TR-11).

LSU-T-P21 "Control of a High Order Plant Using a Time Optimal Second Order Switching Curve", by C. F. Moore, C. L. Smith, and P. W. Murrill, ISA Transactions, Vol. 8, No. 3 (1969), pp. 186-191, (same as LSU-T-TR-14).

LSU-T-P22 "Tuning Controllers for Set-Point Changes", by A. A. Rovira, P. W. Murrill, and C. L. Smith, Instruments and Control Systems, Vol. 42, No. 7, (December 1969), pp. 67-69, AD 699050, AFOSR 70-0025TR.

LSU-T-P23 "An Advanced Tuning Method", by A. M. Lopez, C. L. Smith, and P. W. Murrill, British Chemical Engineering, Vol. 14, No. 11 (November 1969), pp. 1554-1555, AD 688791, AFOSR 69-1410TR, (same as TR-1).

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LSU-T-P28   "Modified PI Algorithm for Digital Control", by A. A. Rovira, P. W.
            Murrill, and C. L. Smith, Instruments and Control Systems, Vol. 43,
            No. 8, August 1970, p. 101, (same as LSU-T-TR-34).

LSU-T-P29   "Rapid Method for Calculating Reactor Temperature Profiles", by
            C. D. Fournier and F. R. Groves, Jr., Chemical Engineering,
            June 15, 1970.

LSU-T-P30   "Proportional Navigation vs. an Optimally Evading, Constant-Speed
            Target in Two Dimensions", by Paul M. Julich and David A. Borg,
            Journal of Spacecraft and Rockets, Vol. 7, No. 12, December 1970,
            pp. 1454-1457.

LSU-T-P31   "Digital Control of Industrial Processes", by Cecil L. Smith,
            September 1970, Computing Surveys, Vol. 2, No. 3, Sept. 1970.

LSU-T-P32   "Hybrid Computation of Autocorrelation Functions", by Edgar C.
            Tacker and Thomas D. Linton, Simulation, March 1970.

LSU-T-P33   "Computer Simulation to Evaluate Control Strategies," by A. B.
            Corripio and C. L. Smith, Instruments and Control Systems, Vol. 44,
            No. 1, Jan. 1971, pp. 87-91.

PAPERS PRESENTED AT MEETINGS

LSU-T-M1 "A Comparison of Optimization Techniques in the Development of Predictor Models", by B. L. Ramaker, P. W. Murrill, and C. L. Smith, American Institute of Chemical Engineers, National Meeting, Tampa, Florida, May 19-22, 1968.

LSU-T-M2 "The Enhancement of Engineering Education and Research Using Analog and Hybrid Computation", D. B. Greenberg, No Proceedings published, American Society for Engineering Education, Annual (National) Meeting, Los Angeles, June 17-20, 1968.

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LSU-T-M4 "Determination of Dynamic Model Parameter Using Quasilineariza-tion" B. L. Ramaker, Raul W. Murrill, and Cecil L. Smith, Proceedings of the Second Hawaii International Conference on System Sciences, Honolulu, Hawaii, January 22-25, 1969.

LSU-T-M5 "Improving the Performance of Digital Control Loops", C. F. Moore, P. W. Murrill and C. L. Smith, 4th Annual Conference on the Use of Digital Computers in Process Control, Louisiana State University, Baton Rouge, Louisiana, Feb 12-14, 1969.

LSU-T-M6 "Formulating the Nonlinear Least Square Model Regression for Fast On-Line Analysis", C. F. Moore, C. L. Smith, and P. W. Murrill, presented at the 64th National AIChE Meeting, New Orleans, March 16-20, 1969, AD 689130, AFOSR 69-1407TR.

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LSU-T-M8 "Proportional Control Systems", U. D. Shendrikar, C. L. Smith, and P. W. Murrill, presented at the First Southeastern Conference on Systems Theory, Blacksburg, Virginia, May 5-6, 1969, AD 688794, AFOSR 69-1413TR, (same as TR-4).

LSU-T-M9 "A Study of Optimal Evasive Maneuvers Against Air-to-Air Missiles", by P. M. Julich and D. Borg, presented at the First Southeastern Conference on Systems Theory, Blacksburg, Virginia, May 5-6, 1969, (same as TR-10).

LSU-T-M10 "Application of Simulation to the Generalized Optimization of Process Control Systems", by C. L. Smith and P. W. Murrill, presented at the Conference on Applications of Continuous System Simulation Languages, San Francisco, July 1, 1969, (same as TR-15).

LSU-T-M11 "Advanced Concepts for Computer Control Systems" by C. L. Smith and P. W. Murrill, presented at the Computer Control Workshop at the 1969 JACC, Boulder, Colorado, August 4, 1969, (in SR-15, AD 696149, AFOSR 69-2729TR).

LSU-T-M12 "An Optimal Controller for Multivariable Systems Subject to Disturbance Inputs", by C. L. Smith and P. W. Murrill, presented at the 1969 JACC, Boulder, Colorado, August 7, 1969.

LSU-T-M13 "Input Excitation Effects on Experimental Dynamic Model Development", by C. W. Ritter, C. L. Smith, and P. W. Murrill, presented at the 66th National AIChE Meeting, Portland, Oregon, August 26, 1969, (same as TR-9).

LSU-T-M14 "Hybrid Computation at Louisiana State University", by A. B. Corripio, presented at the annual meeting of the Southeastern Section of the Analog/Hybrid Computers Educational Users Group, Clemson, South Carolina, November 6, 1969, AD 705362, AFOSR 70-1092TR.

LSU-T-M15 "The Application of Non-Interacting Control Theory to a Continuous Multivariable System", by J. A. Planchard and V. J. Law, presented at the 1969 IFAC Meeting, Warsaw, Poland, June 16-21, 1969.

LSU-T-M16 "Application of Simulation in the 70's" by E. C. Tacker, presented at the Southwestern Simulation Council Meeting at the Manned Spacecraft Center in Houston, Texas, September 19, 1969.

LSU-T-M17 "Comparison of Optimal and Suboptimal Controllers, by J. A. Miller, C. L. Smith, and P. W. Murrill, presented at the Third Hawaii Conference on System Sciences, Honolulu, Hawaii, January 14-16, 1970.

LSU-T-M18 "An Improved General Purpose Algorithm for Direct Digital Control", by C. F. Moore, C. L. Smith, and P. W. Murrill, presented at the Third Hawaii Conference on System Sciences, Honolulu, Hawaii, January 14-16, 1970, AD 701588, AFOSR 70-0472.

LSU-T-M19 "Studies in Digital Automata", by C. L. Smith, presented at the Third Hawaii Conference on System Sciences, Honolulu, Hawaii, January 14-16, 1970, AD 701587, AFOSR 70-0471TR.

LSU-T-M20 "Mode Selection and Tuning of Analog Controllers", by A. B. Corripio and C. L. Smith, presented at the 3rd Biannual Instrument Maintenance Clinic, ISA, Baton Rouge, Louisiana, May 2, 1970.

LSU-T-M21 "Use of Computer Simulation to Evaluate Control Strategies for Chemical Process", by A. B. Corripio and C. L. Smith, presented at the 1970 Summer Computer Simulation Conference, Denver, Colorado, June 10-12, 1970.

LSU-T-M22 "Use of Hybrid Computer to Evaluate Control Strategies for Chemical Process", by A. B. Corripio and C. L. Smith, presented at the AICA/IFIP 1970, Conference on Hybrid Computation, Munich, Germany, August 31-September 4, 1970.

LSU-T-M23   "Hybrid Simulation of an Optimal Stochastic Control System", by
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LSU-T-M27   "Digital and Hybrid Simulation of a Discrete-Time Optimal Nonlinear
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Fourth Hawaii International Conference on System Sciences, Honolulu,
Hawaii, January 12-14, 1971.

LSU-T-M28   "On Comparing Numerical Techniques for Computing Optimal Programs",
by P. M. Julich and P. Simosa, Presented to Nineth Annual IEEE
Region III Convention, April 26-28, 1971, Charlottesville, Virginia.

LSU-T-M29   "Computer-Aided Design of Chemical Reactor Control Systems", Proceedings
of the Fifth Annual Princeton Conference on Information Sciences and
Systems, by E. C. Tacker, T. D. Linton, and A. B. Corripio, Princeton,
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LSU-T-M30   "A Simulation Study of Stochastic and Conventional Controllers for
a Chemical Reactor", by E. C. Tacker, T. D. Linton, A. B. Corripio,
Proceedings of the Third Annual Southeastern Symposium on System
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LSU-T-M31   "Design of Computer Control Systems Using Modern Control and Estimation
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1971 Symposium on Applications of Computers, Lafayette, Indiana,
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LSU-T-M32   "Computer—Aided Analysis of Stochastic Processes", by E. C. Tacker
and T. D. Linton, Proceedings of the Purdue 1971 Symposium on Applica-
tions of Computers, Lafayette, Indiana, April 26-28, 1971.

LSU-T-M33   "Computer Simulation of an Optimal Stochastic Control Algorithm Derived
from Functional Analysis", by by E. C. Tacker, Presented at the
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LSU-T-M34 "Models and Performance Functionals for Load Frequency Control in Interconnected Power Systems", Presented for the IEEE 1971 Conference on Decision and Control, December 1971, by P. M. Julich, T. O. Tan, and E. C. Tacker.

LSU-T-M35 "Optimal Feedback Control of Nonlinear Systems Through Dynamic Programming," by A. B. Corripio, C. L. Smith, and P. W. Murrill, Proceedings of the Fourth Hawaii International Conference in Systems Sciences, Honolulu, January, 1971.

LSU-T-M36 "Dynamic Programming and Approximation in Policy Space for Optimal Feedback Control of Nonlinear Systems," by A. B. Corripio, C. L. Smith and P. W. Murrill, presented at the 68th National Meeting of the American Institute of Chemical Engineers, Houston, Texas, March 1971.

LSU-T-M37 "On-Line Identification of Distillation Column Dynamics," by A. B. Corripio and C. L. Smith, Instrumentation in the Chemical and Petroleum Industries, Vol. 7, Proceedings of the Twelth Instrument Society of American Chemical and Petroleum Instrumentation Symposium, Houston, Texas, April 1971.

LSU-T-M38 "Psuedo-Optimal Closed Loop Control of Nonlinear Systems via a Hybrid Technique," by C. D. Fournier, F. R. Groves, Jr., and A. B. Corripio, Proceedings of the 1971 Joint Automatic Control Conference, St. Louis, Missouri, August 1971.

LSU-T-M39 "On-Line Model Identification and Control Using the Kalman Filter," by R. A. Mollenkamp, C. L. Smith, and A. B. Corripio, Proceedings of the 1971 Joint Automatic Control Conference, St. Louis, Missouri, August 1971.

LSU-T-M-40 "Computational Aspects of a Generalized Algorithm for the Optimal Control of Continuous-Time Nonlinear Stochastic Systems", by E. C. Tacker, T. D. Linton, C. W. Sanders, Jr. and C. C. Lee, Proceedings of the Second Symposium on Nonlinear Estimation Theory and Its Applications, San Diego, California, September 13-15, 1971.

LSU-T-M41 "A Gradient Method for the Optimal Control Problem of Bolza", by S. J. Wang and E. C. Tacker, Proceedings of the Ninth Allerton Conference on Circuit and System Theory, Urbana, Illinois, October 6-8, 1971.

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LSU-T-SR1   Optimization of System Response, A. M. Lopez, Ph.D. Dissertation,
             Department of Chemical Engineering, Louisiana State University,
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LSU-T-SR2   Proceedings of the Third Annual Conference on the Use of Digital
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LSU-T-SR3   Analog Simulation of Induced Disturbances on Feedback Control
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LSU-T-SR4   Application of Convolution Techniques in the Solution and
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             Thesis, Department of Mechanical Engineering, Louisiana State
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LSU-T-SR6   Stochastic Control of Chemical Processes, Brian Ramaker, Ph.D.
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LSU-T-SR8   Study to Relate the Variances of Missile Impact Parameters to
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             Technical Report Submitted to AFATL, Eglin AFB, November 21, 1968.

LSU-T-SR9   Selected Problems in the Design and Implementation of Direct
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             of Chemical Engineering, Louisiana State University, Baton Rouge,
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LSU-T-SR10   A Lumped Parameter Approximation for Distributive Parameter Systems,
             Luis A. Gonzalez, M.S. Thesis, Department of Chemical Engineering,
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LSU-T-SR11   A Study of Pursuit-Evasion Strategy, The Planar Case for Air-Air
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LSU-T-SR13 Control of Batch Crystallization, E. J. Lui, M.S. Thesis, Department
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LSU-T-SR14 Applying Feedback and Feedforward Control, J. A. Miller, Ph.D.
            Dissertation, Department of Chemical Engineering, Louisiana State
            University, Baton Rouge, January, 1970, AD 696147, AFOSR 69-2727TR.

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            Louisiana, January 1970.

LSU-T-SR20 A Min-Max Study of Aim Angle for a Proportional Navigation Missile,
            G. P. Orgeron, M.S. Thesis, Department of Electrical Engineering,
            Louisiana State University, Baton Rouge, May 1970, AD 708167, AFOSR
            70-1808TR.

LSU-T-SR21 Numerical Solutions of Singular Control Problems, P. Simosa, M.S.
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LSU-T-SR22 Approximate Methods for the Optimal Control of Nonlinear Systems,
            Charles D. Fournier, Ph.D. Dissertation, Department of Chemical
            Engineering, Louisiana State University, Baton Rouge, August 1970,

LSU-T-SR23 Mathematical Model for the Generation of the Electrocardiogram Lead 1,
            Enrique Lopez, M.S. Thesis, Department of Chemical Engineering, Louisiana
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LSU-T-SR24 <u>Analog Simulation of a 15th Order Rate Control Loop With Widely Separated Eigenvalues</u>, C. C. Lee, C. W. Sanders, P. M. Julich, and E. C Tacker, Departments of Electrical and Chemical Engineering, Louisiana State University, Baton Rouge, Louisiana, April 1971.

LSU-T-SR25 <u>Control of High-Order Systems Using Simple Models</u>, Robert A. Mollenkamp, Ph.D. Dissertation, Department of Chemical Engineering, Louisiana State University, Baton Rouge, Louisiana, January 1971.

LSU-T-SR26 <u>Interception of an Optimally Evading Target</u>, Michael T. Miesch, M.S. Thesis, Department of Electrical Engineering, May 1970.

B. General Distribution

LSU-T-TR-1   "An Advanced Tuning Method", Alfredo M. Lopez, Cecil L. Smith, and Paul W. Murrill, AD 688791, AFOSR 69-1410TR (same as P23).

LSU-T-TR-2   "Optimum Tuning of a Slow Sampling Digital Control Algorithm", Alfredo M. Lopez, Paul W. Murrill, and Cecil L. Smith, AD 688792, AFOSR 69-1411TR.

LSU-T-TR-3   "Design of Digital Control Algorithms Using Time Domain Specifications", L. P. Neumann, C. L. Smith, and P. W. Murrill, AD 688793, AFOSR 69-1412TR.

LSU-T-TR-4   "Proportional Control Systems", U. D. Shendrikar, C. L. Smith, and P. W. Murrill, AD 688794, AFOSR 69-1413TR, (same as M8).

LSU-T-TR-5   "Comparing and Tuning PI and PID Digital Control Algorithms", U. D. Shendrikar, C. L. Smith, and P. W. Murrill, AD 688795, AFOSR 69-1414TR.

LSU-T-TR-6   "Determination of Dynamic Model Parameters Using Quasilinearization", B.L. Ramaker, C. L. Smith, and P. W. Murrill, AD 688770, AFOSR 69-1415TR, (same as P25).

LSU-T-TR-7   "Development of Predictor Models", by B. L. Ramaker, C. L. Smith, and P. W. Murrill, AD 688797, AFOSR 69-1416TR.

LSU-T-TR-8   "Applying Feedforward Control", J. A. Miller, P. W. Murrill, and C. L. Smith, AD 688798, AFOSR 69-1417TR.

LSU-T-TR-9   "Input Excitation Effects on Experimental Dynamic Model Development", O. R. Ritter, C. L. Smith, and P. W. Murrill, AD 688799, AFOSR 69-1418TR, (same as M13).

LSU-T-TR-10 "A Study of Optimal Evasive Maneuvers Against Air-to-Air Missiles", P.M. Julich and D. Borg, AD 688800, AFOSR 69-1419TR, (same as M9).

LSU-T-TR-11 "Circular Arrays of Radial and Tangential Dipoles for Turnstile Antennas", J. L. Hilburn, AD 6C..01, AFOSR 69-1420, (same as P20).

LSU-T-TR-12 "Formulating the Least Square Regression for Continuous Analysis", C. F. Moore, C. L. Smith, and P. W. Murri 1, AD 688803, AFOSR 69-1421TR.

LSU-T-TR-13 "An Optimal Controller for Multivariable Systems Subject to Disturbance Inputs", C. L. Smith and P. W. Murrill, AD 688803, AFOSR 69-1422TR.

LSU-T-TR-14 "Control of a High Order Plant Using a Time Optimal Second Order Switching Curve", C. F. Moore, P. W. Murrill, and C. L. Smith, AD 688804, AFOSR 69-1423TR (same as LSU-T-P21).

LSU-T-TR-15 "Application of Simulation to the Generalized Optimization of
Process Control Systems", P. W. Murrill and C. L. Smith,
AD 688805, AFOSR 69-1424TR.

LSU-T-TR-16 "Controlling a Very Noisy System", B. L. Ramaker, C. L. Smith,
and P. W. Murrill, AD 688806, AFOSR 69-1425TR.

LSU-T-TR-17 "Prediction of Response of First Order Nonlinear System with
Proportional Control", F. R. Groves, June 1969, AD 694041,
A.OSR 69-2383TR.

LSU-T-TR-18 "Prediction of Response of First Order Nonlinear Systems with Time
Delays, Part I: Proportional Control", F. R. Groves, June 1969,
AD 694042, AFOSR 69-2382TR.

LSU-T-TR-19 "Adjustment of Controllers", C. L. Smith and P. W. Murrill, July
1969, AD 694043, AFOSR 69-2381TR.

LSU-T-TR-20 "Improving Controller Settings Based on Open Loop Methods", J. H.
Dube, C. L. Smith, and P. W. Murrill, July 1969, AD 694044,
AFOSR 69-2380TR.

LSU-T-TR-21 "Tuning Controllers for Set Point Changes", by A. A. Rovira,
P. W. Murrill, and C. L. Smith, September 1969, AD 700053,
AFOSR 70-0088TR.

LSU-T-TR-22 "Optimal Isothermal Temperature for Reversible Reactions", C. D.
Fournier and F. R. Groves, October 1969, AD 700054, AFOSR 70-
0089TR.

LSU-T-TR-23 "Multidimensional Optimization Using Pattern Search", C. F. Moore,
C. L. Smith, and P. W. Murrill, October 1969, AD 702842, AFOSR
70-0728TR.

LSU-T-TR-24 "Effects of Parameter Variations on the Capability of a Proportional
Navigation Missile Against an Optimally Evading Target in the
Horizontal Plane", by Paul M. Julich and David A. Borg, October 1969,
AD 700099, AFOSR 70-0085TR.

LSU-T-TR-25 "Proportional Navigation vs. an Optimally Evading Constant Speed
Target in Two Dimensions", by Paul M. Julich and David A. Borg,
October 1969, AD 702821, AFOSR 70-0727TR.

LSU-T-TR-26 "Approximate Currents for Circular Arrays of Radial and Tangential
Dipoles", by John L. Hilburn, October 1969, AD 700098, AFOSR
70-0086TR.

LSU-T-TR-27 "Criteria for Evaluating Fourier Transform Computational Results",
by Carlos R. Dollar, Paul W. Murrill and Cecil L. Smith, October
1969, AD 700055, AFOSR 70-0090TR.

LSU-T-TR-28 "Pulse Testing via the Fast Fourier Transform", Carlos R. Dollar, Cecil L. Smith and Paul W. Murrill, October, 1969, AD 700056, AFOSR 70-0087TR.

LSU-T-TR-29 "Approximate Optimal Control Using Sensitivity Coefficients", William H. Pusch, Cecil L. Smith, and P. W. Murrill, December 1969, AD 702083, AFOSR 70-0584TR.

LSU-T-TR-30 "An Application of Optimal Control Theory", John A. Miller, Cecil L. Smith, and Paul W. Murrill, December 1969, AD 702084, AFOSR 70-0583TR.

LSU-T-TR-31 "Dynamic Programming and Approximation in Policy Space for Optimal Feedback Control of Nonlinear Systems", by Armando B. Corripio, Cecil L. Smith and Paul W. Murrill, December 1969, AD 7020, AFOSR 70-0581TR.

LSU-T-TR-32 "Approximate Optimal Closed Loop Control of Nonlinear Systems Via Parameter Search", by Charles D. Fournier and Frank R. Groves, December 1969, AD 702086, AFOSR 70-0580.

LSU-T-TR-33 "An Air to Surface Missile Simulation Using a Digital Simulation Language", by G. D. Whitehouse, Mario Caluda, and A. J. McPhate, December 1969, AD 70208, AFOSR 70-0600TR.

LSU-T-TR-34 "The Slow Set Point Control Algorithm", by A. A. Rovira, P. W. Murrill, C. L. Smith, February, 1970, AD 708520, AFOSR 70-1803TR.

LSU-T-TR-35 "Comparison of Optimal and Suboptimal Controllers", by J. A. Miller, C. L. Smith, and P. W. Murrill, March 1970, AD 714615, AFOSR 70-2598TR.

LSU-T-TR-36 "Analog Simulation of an Air Force Air to Air Missile Guidance System", by David B. Greenberg, May 1969, AD 717745, AFOSR 70-2817TR.

LSU-T-TR-37 "Hybrid Simulation of an Optimal Stochastic Control System", by Edgar C. Tacker and Thomas D. Linton, August, 1970, (same as LSU-T-M23) AD 714613, AFOSR 70-2592TR.

LSU-T-TR-38 "Hybrid and Digital Simulation of Optimal Stochastic Control Systems", by Edgar C. Tacker and Thomas D. Linton, August 1970, (same as LSU-T-M24) AD 714614, AFOSR 70-2593TR.

LSU-T-TR-39 "A Discussion of the Application of Modern Optimal Control Theory to a Power System", by Thomas W. Reddoch and Paul M. Julich, September, 1970, AD 716552, AFOSR 70-2813TR.

LSU-T-TR-40 "Digital and Hybrid Simulation of a Bayes-Optimal Nonlinear Filter", by Edgar C. Tacker and Thomas D. Linton, September, 1970, AD 716446, AFOSR 70-2829TR.

LSU-T-TR-41 "A Direct Finite Difference Method for Optimal Control Problems", by C. D. Fournier and F. R. Groves, Jr., September, 1970, AD 716546, AFOSR 70-7816TR.

LSU-T-TR-42   "On-Line Model Identification and Control Using the Kalman
              Filer", Robert A. Mollenkamp, Cecil L. Smith, and Armando B.
              Corripio, January 1971, AD 718993, AFOSR 71-0315TR.

LSU-T-TR-43   "Discrete Model Identification Based on Correlation Functions",
              Brian Froisy, Cecil Smith, and Armando Corripio, January
              1971, AD 718995, AFCSR 71-0361TR.

LSU-T-TR-44   "Computer Evaluation of Stochastic and Deterministic Controller
              Designs for a Chemical Reactor", by Edgar C. Tacker, Thomas D.
              Linton, and Armando B. Corripio, February 1971.

LSU-T-TR-45   "Optimization Studies of Aircraft Control Variables", by Mario
              Caluda, G. D. Whitehouse, and A. J. McPhate, May 1971.

LSU-T-TR-46   "Spectral Analysis of Transient Data with Application to Auto-
              Pilot Parameter Studies", by Raymond Speeg, G. D. Whitehouse,
              and A. J. McPhate, May 1971.

PROGRESS REPORTS

LSU-T-PR1   November 30, 1967, Quarterly Progress Report

LSU-T-PR2   February 29, 1968, Quarterly Progress Report

LSU-T-PR3   May 31, 1968, Quarterly Progress Report

LSU-T-PR4   August 31, 1968, Quarterly Progress Report

LSU-T-PR5   November 30, 1968, Quarterly Progress Report

LSU-T-PR6   February 28, 1969, Quarterly Progress Report

LSU-T-PR7   May 31, 1969, Quarterly Progress Report

LSU-T-PR8   August 31, 1969, Quarterly Progress Report

LSU-T-PR9   November 30, 1969, Quarterly Progress Report

LSU-T-PR10 February 28, 1970, Quarterly Progress Report

LSU-T-PR11 May 31, 1970, Quarterly Progress Report

LSU-T-PR12 August 31, 1970, Quarterly Progress Report

LSU-T-PR13 November 30, 1970, Quarterly Progress Report

LSU-T-PR14 February 28, 1971, Quarterly Progress Report

LSU-T-PR15 May 31, 1971, Quarterly Progress Report

LSU-T-PR16 August 31, 1971, Quarterly Progress Report

LSU-T-PR17 November 30, 1971, Quarterly Progress Report

Progress Reports

The following reports cover the progress made by individual investigators during the past quarter.

Project Director: J. A. Planchard

Graduate Student: Mohamad Karbassian

Project Title: Application of the Principle of Invariance to

                     a Distributed Parameter System

The object of this study is to determine whether existing

identification techniques can be utilized on systems described by

partial differential equations in order to apply advanced control

methodology such as the principle of invariance.

The system chosen for study is a shell and tube heat exchanger

in which the control objective is to maintain the existing concen-

tration of H_2O in a hydrogen stream on the face of upsets in the

entering stream concentration and temperature.

The analytical frequency response of this system has been

determined and compared to that obtained utilizing a Taylor

diffusional model. The results indicate that the Taylor diffusional

model is not a valid representation of the system.

A stochastic identification procedure will also be utilized

to model the system.

Project Director: J. A. Planchard

Graduate Students: T. Perkins and J. Barzinji

Project Title: Modeling the Human Operator in a Tracking Task

A two mode human operator model (tracking and acquisition) has been successfully developed that predicts the mean performance of a human operator in a compensatory tracking task. Data for verification of the model was obtained by utilizing the real time capability of the LSU hybrid computer.

Correlations are presently being developed to predict the variance of the operator in terms of certain key parameters of the system.

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Project Director: J. A. Planchard

Graduate Student: Ahmad Shariat

Project Title: The Optimal Control of a Distributed

                      Parameter System

     This project has been complet 1 and the dissertation mailed to the Themis technical monitor. A Themis report summarizing the work is being prepared.

Project Directors: A. B. Corripio and C. L. Smith

Graduate Student: Frank T. Davis

Project Title: The Simulation of Large Industrial

        Centrifugal Compressors

An unsteady-state model of a constant speed centrifugal compressor has been developed and programmed on the IBM-360 utilizing CSMP and on the XDS-Σ5 utilizing SL1. The model includes suction throttling for discharge pressure control and bypass for surge control. It is based upon design data obtained from one of the major manufacturers of centrifugal compressors. A paper is being completed for presentation at the Third Annual Pittsburg Modeling and Simulation Conference on April 24 and 25 of 1972.

The Enjay Chemical Company has released the design information necessary to model a variable speed centrifugal compressor and its associated steam turbine driver. The information should be forthcoming from Dresser Industries and General Electric as they have been awaiting the release from Enjay. This information will be utilized to develop the variable speed centrifugal compressor model.

· This project is nearing completion with the expected completion date being June 1, 1972.

Project Director: P. M. Julich

Graduate Students: D. A. Borg and D. K. Jones *

Project Title: Simulation and Analysis of a Stiff Control System

Originating Organization: Air Force Weapon Laboratory
                           Kirtland Air Force Base, N. M.

Efforts are being made by David Jones to serially simulate the
two axes of the system under consideration. This is necessary because
of the limited equipment available on the EAI 680. The changes in
the elevation axis simulation requested by personnel at Kirtland have
been completed and checked out. David Borg is working on a method
for systematically designing digital compensation for the system.
It is necessary to develop high accuracy methods of operation on the
digital computer to avoid serious roundoff errors. The development
of these methods has been partially completed during the report period.

Design of a bang-bang controller continues. Switching surfaces
to give a reasonable overshoot have been obtained since the last
progress report but effort continues because the inner and outer
azimuth's still do not track each other close enough to avoid upsetting
the gyro's.

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* 2nd. Lieutenant on active duty with Air Force stationed at LSU.

Project Director: P. M. Julich

Graduate Students: T. Reddoch and George Buchert

Project Title: Optimization oi : ~orconnected Control Systems

This project is a continuing study of multivariable control methods applied to control systems which are interconnected studies of symmetry of the cost function and resulting control strategy have been made. Comparisons of control laws designed for independent systems which are then interconnected have been made with results obtained from optimizing the overall system.

A method for implementing the parameter optimization algorithm proposed by Athans and Levine has been programmed by George Buchert. Problems were encountered initially because of convergence difficulties. These problems have been solved during .e past report period however and the method is operational. This method will be compared with results obtained from solution of matrix Riattis equation which requires feedback of all control variables.

A paper applying the results of this work to interconnected power control systems will be presented April 11 at IEEE Region III Meeting in Knoxville, Tennessee.

Project Director: P. M. Julich

Graduate Student: Charles Ward*

Project Title: Guidance Laws for Interception of Optimally

Erading Targets

This project is a continuation of studies into modification of

proportional navigation systems to improve the capability of

intercepting an optimally evading target. Earlier studies pointed

out some inherent weaknesses of proportional navigation against

maneuvering targets. Earlier studies showed that proportional plus

pursuit navigation might result in improved capture capability.

This study is examining proportional plus pursuit navigation against

optimally evading targets in the horizontal plane.

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* 2nd. Lieutenant on active duty with USAF; stationed at LSU.

1. Meisch M. T., Interception of Optimally Evading Target, LSU-T-SR26.
   May, 1970.

Project Director: Edgar C. Tacker

Graduate Student: Chi C. Lee*

Project Title: Optimization of Interconnected Power Systems -
                      The Load Frequency Control Problem

We have now compiled a number of cases wherein stochastic

controllers using our model formulation significantly out perform

deterministic optimal controllers. Our results thus far appear

(or will appear) in the references given below.

References

1. Tacker, E. C., Lee, C. C., Julich, P. M., and Tan, T. O.,
    "Design and Simulation of an Optimal Stochastic Controller for
    a Composite Two-Area Power System", Proceedings of the 1971
    IEEE Conference on Decision and Control, Miami, Florida,
    December 16-18, 1971.

2. Tacker, E. C., Lee, C. C., Julich, P. M., and Tan, T. O.,
    "Models and Optimal Stochastic Controller Designs for Inter-
    connected Power Systems", Proceedings of the Region III IEEE
    Conference, Knoxville, Tenn., April, 1972.

3. Reddoch, T. W., Julich, P. M., Tan, T. O., and Tacker, E. C.,
    "Optimization of the Load Frequency Controller via Infinite Bus
    Analysis", Proceedings of the Region III IEEE Conference, Knoxville,
    Tenn., April, 1972.

4. Tacker, E. C. and Lee, C. C., "Optimum Load Frequency Control of
    Interconnected Electric Energy Systems Subjected to Stochastic
    Disturbances", Manuscript in progress.

* Supported by the LSU Division of Engineering Research and the
   Department of Electrical Engineering.

Project Director: Edgar C. Tacker

Graduate Students: Thomas D. Linton and Charles W. Sanders, Jr.*

Project Title: Computatiɔnal Aspects of Functional Space-

Derived Cptimal Stochastic Controllers

Further results have been obtained for the problem

described in the May 31, 1971 Progress Report both in the

open-loop case and for a quasi-closed-loop controller.   These

results will be reported in a future Themis report as well as

in References 1 - 5.

References

1. Tacker, E. C., C. W. Sanders, Jr., T. D. Linton and
    C. C. Lee, "Computational Aspects of a Generalized Algorithm
    for the Optimal Control of Continuous Time Systems," Proceedings
    of the Second Symposium on Nonlinear Estimation and its Applications,
    San Diego, California, September 13-15, 1971 .

2. Tacker, F. C., C. W. Sanders, Jr., and T. D. Linton,
    "Function-Space Derived Algorithms for the Control of
    Continuous Time Nonlinear Stochastic Systems," Proceedings
    of the 1971 IEEE Conference on Decision and Control,
    Miami Beach. Florida, December 16-18, 1971.

3. Tacker, E. C., C. W. Sanders, Jr., and T. D. Linton,
    "An Optimal Control Algorithm for Continuous Time Stochastic
    Systems," Submitted to the IEEE Transactions on Automatic
    Control.

4. Tacker, E. C., C. W. Sanders, Jr., and T. D. Linton, "Open Loop
    Optimal Control Algorithms for Continuous Time Stochastic Control
    Systems", Proceedings of the Fourth Southeastern Symposium on
    System Theory, Lexington, Kentucky, April, 1972.

5. Tacker, E. C., C. W. Sanders, Jr., and T. D. Linton, "Some
    Computational Aspects of Open Loop Optimal Feedback Control of
    Continuous Time Stochastic Systems", Submitted for publication.
    (1972 Joint Automatic Control Conference and IEEE Transactions
    on Automatic Control).